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BEST PRACTICE PROGRAMME

Good Practice Guide 54

ELECTRICITY SAVINGS IN HOSPITALS

A GUIDE FOR ENERGY AND ESTATE MANAGERS

The NHS spends over £300 million a year on energy in the UK. Electricity consumption accounts for around £125 million of this total and is rising annually at between 6% and 8%. However, there are many cost effective ways in which electricity consumption can be reduced, resulting in cost, environmental (local and global) and quality benefits. The Energy and/or Estates Manager can have a very important role in controlling this consumption.

Purpose of the Guide

The Guide is targeted at the Energy Manager or Estates Manager responsible for implementing energy saving programmes and presents:

- An overall strategy for the control and reduction of electricity consumption and costs.
- outline details of many different consumption and cost reducing opportunities.

It indicates how electricity savings of up to 15% can be made by implementing projects with paybacks of between one and three years. These savings can represent about £40,000 for some directly managed Units or Trusts, and can be accompanied by many other benefits to management.

Electricity Consumption and Costs

Figure 1 gives a breakdown of energy consumption, cost and CO_2 production in the NHS. It shows that electricity, whilst being only 13% of energy consumption, accounts for 42% of cost and 29% of the total CO_2 production. If the present trends continue, in five years time electricity will account for 50% of cost. To date, a large proportion of energy saving initiatives within the NHS have been aimed at reducing fossil fuel use because:

- space heating often presents the easiest option for reducing energy consumption and can be easily targeted;
- electricity has been perceived as an efficient energy form and inefficient use of it has often not been fully recognised.

Saving Targets

The Department of Health has set Authorities a target of saving 15% of energy consumption over the next five years. In a recent study of 450 hospitals, the Audit Commission identified scope for energy savings of 15%. In their document "Energy Saving in the NHS", they provide tables of performance indicators against which comparisons can be made. These tables can also be used to develop targets for premises of particular types eg smaller acute hospitals. Targets represent only the first stage in assessing how well the hospital compares to others. All hospitals are to some extent unique, but there is nearly always room for further improvement, wherever the starting point.

Electricity and the Environment

There is a growing awareness of the damage being done to the environment by the energy we consume in buildings, both locally and through electricity generation at power stations. In the UK about 50% of our carbon dioxide emission is attributable to buildings thereby adding to the worldwide "Greenhouse Effect". The energy used in hospitals produces approximately 7.5 million tonnes of CO_2 each year. Of this some 29% is attributable to electricity consumption. In addition, the oxides of sulphur and nitrogen contribute to "acid rain". There are two ways in which you can help to reduce these emissions — reduce demand, and install combined heat and power.

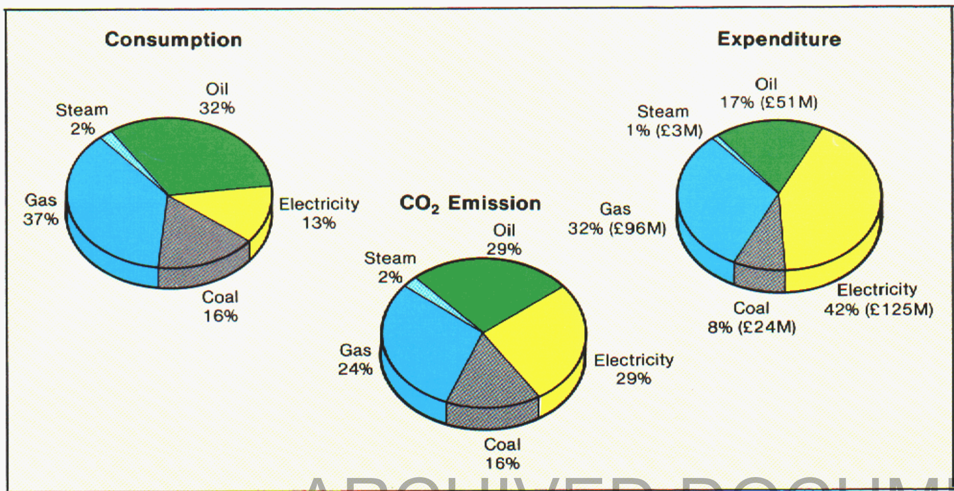

Fig. 1 Electricity Consumption, CO_2 emission and cost in the NHS hospitals in the UK

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

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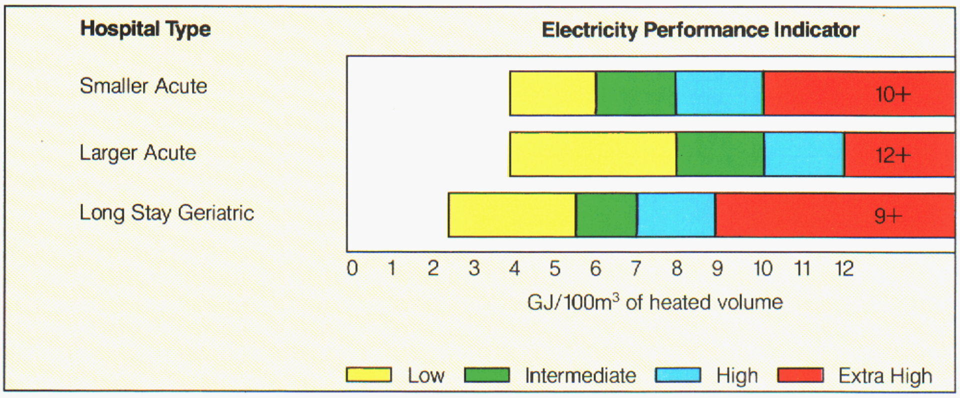


Fig. 2 Annual Electricity Performance Indicators for different types of hospitals.
Source: Audit Commission, "Energy Saving in the NHS" 1991

Overall Strategy

Performance Measurement

The electrical consumption of 450 hospitals has recently been measured by the Audit Commission. Electricity Performance Indicators derived from this work are shown in Figure 2 for three hospital types. The figures show the range of electricity consumption for the four performance categories. Part of this performance spread is due to the different specifications that can apply to each hospital type eg air conditioning instead of natural ventilation, but the range also reflects differences in efficiency of electricity use.

The information should be used as an initial guide to the electrical energy efficiency of a particular building and as an indicator on the need for a more detailed examination at the local level to assess the true scope for saving.

Note: There may occasionally be advantages in expressing performance indicators in terms of primary energy units or in resultant CO_2 emissions. To a first approximation, energy cost equates very roughly to primary energy units and also to CO_2 emissions. In contrast, delivered energy or "consumption" figures can be misleading (see Figure 1). Use of primary energy units would for example show the advantages of CHP more clearly.

The Approach

The achievement of electricity savings requires a structured approach based on a good understanding of the processes that convert and use electricity. To identify all the saving possibilities, the existing usage should be examined with five options in mind.

- Pay less - by ensuring that the optimum tariff is being used and that Maximum Demand and Power Factor are effectively controlled.
- Use less - by ensuring that equipment is controlled to meet the required loads, and is switched off when not needed.
- Convert more efficiently - by using higher efficiency motors and lamps, for example.
- Monitoring and Targeting - experience has shown that electricity savings of 5-7% can be achieved and maintained through a good M&T system that places accountability for energy consumption on those who use it.
- Own generation - the use of Combined Heat and Power plant has been shown to be effective in the NHS.

Unlike heat savings, which tend to arise from two or three major projects on a site, electricity savings come from perhaps twenty or thirty smaller projects. This feature makes the achievement of savings more demanding in terms of time and is a further reason why electricity savings have generally received less attention. Remember that very significant savings can be made by using higher efficiency lamps and motors. For motors GPG 2, (Guidance Notes for Reducing Energy Consumption Costs of Electric Motors and Drive Systems) gives detailed information, including the subject of controls.

Electrical Audit

An audit is required to identify the main electricity using areas. This is done by making an assessment of the main plant ratings and running hours per week. Other EEO Good Practice Guides and the Department of Health ENCODE Guide provide information on such audits. A typical breakdown in a hospital is shown in Figure 3. The precise split depends upon the type of hospital and the extent and sophistication of equipment and services. New hospitals usually have a greater degree of air conditioning, with associated chiller plant, and more extensive ventilation systems. Temporary recording instruments may be used to produce 24 hour demand profiles. These can be extremely useful and often show up surprisingly high base load consumption.

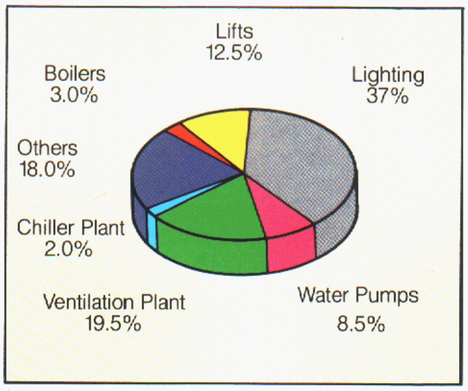


Fig. 3 An example of the disaggregation of electricity use

Figure 4 shows an actual profile with an average base load of over 500kW. In this particular case, it was discovered that the lifts represented 12% of this base load demand and that savings could be made by switching off certain lifts at night. Further savings were made on the ventilation plant which was found to be contributing 30% of the base load. The combination of demand monitoring and assessing individual plant consumptions should lead to a priority list of areas for further investigation. Do not be deterred by the large uncertainties in these measurements. A reasonable first estimate can be all that is required in the early stages.

Electricity Saving Measures

Some of the following examples may not relate to all types of premises but most of them have widespread application.

Lighting

Lighting accounts for 30-50% of electricity usage in a hospital and is therefore the largest overall consumer. Its control is normally left in the hands of hospital staff with no accountability for electrical usage. Lights are often left on unnecessarily when an area is either unoccupied or has sufficient natural light. To minimise running hours, two methods should be considered.

- If the occupation of the area is significantly less than 24 hours per day, automatic time control may be worthwhile, with localised manual overrides located in convenient positions for the occupants.
- In areas with good natural lighting, photocell control should be adopted especially in corridors and zones near windows. Paybacks of 2-3 years can be achieved but are dependent on the switching arrangements. More information is given in Building Research Establishment Digest 272, Lighting Controls and Daylight Use.

Modern efficient lighting should be fitted in areas where:

- there is high lighting utilisation;
- the existing tubes and luminaires are becoming expensive to replace and maintain.

The following points should be taken into account when retrofitting fluorescent lamps:

- Replacement of 38mm tubes by the 26mm slimline type will give an electricity saving of 10-12% for the same level of illuminance
- Existing control gear will have to be checked, possibly using a lighting specialist, before arranging a direct lamp replacement
- High frequency slimline tubes are only likely to be justifiable for new installations. The payback for retrofit will almost certainly exceed three years taking energy cost savings alone
- High reflectivity reflectors should be fitted wherever possible to reduce the number of lamps.

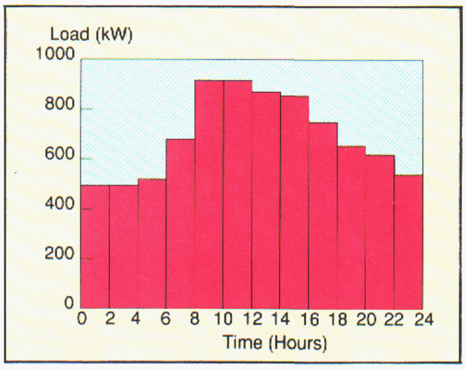


Fig. 4 Daily Demand Profile

The replacement of tungsten filament lamps by compact fluorescents can reduce consumption by 75% but will only give a good payback in highly used locations. Where colour rendering is not important eg boilerhouse, laundry, gymnasium and external areas, conversion to high pressure sodium lamps will prove cost effective.

All of the above improvements for energy efficient lighting are normally accompanied by improvements to the internal environment, and hence the attractiveness of the hospital to staff and patients.

Ventilation Plant

In modern hospitals, ventilation plant can account for more than 30% of total site consumption. To assess the total load, a register of all the ventilation plant kW ratings should be made. Running hours can be minimised by fitting automatic time control to those plants feeding areas not requiring full time ventilation such as X-ray department, administration offices, kitchen and canteen, corridors, stairways, etc. Stand alone time control can be used for the supply and extract fans as well as the associated heater battery supply pumps where fitted.

Operating theatre ventilation is normally sized to provide around 20 air changes per hour when the theatre is in use. Lower air change rates can be used at other times and the use of two speed fans should be investigated. An override should be installed so that full rate ventilation can be restored should the theatre be required in an emergency. A warning light, fitted in view of the hospital service staff, can be used to show when the override has been used and will serve as a reminder to reset the fan speed to the lower rate when the theatre is empty.

Ventilation fans with Variable Speed Drives (VSD) are often not suitable for hospitals since fixed ventilation rates have to be maintained. An application may arise for VSD where a single air handling unit is supplying a number of areas with different hours of occupation. By fitting time controlled dampers to the ventilation ducts, a VSD equipped fan could be controlled on duct pressure.

Pumps

Medium Temperature Hot Water (MTHW) and Low Temperature Hot Water (LTHW) pumps can represent up to 10% of electrical usage in a hospital. Heating circuits often consist of 20-25 LTHW pumps supplying wards, administration areas and air handling units. Pump sizes vary from 500W to 5kW dependent upon the size of the area being heated. A typical layout for a LTHW circuit is shown in Figure 5. The primary pump can be

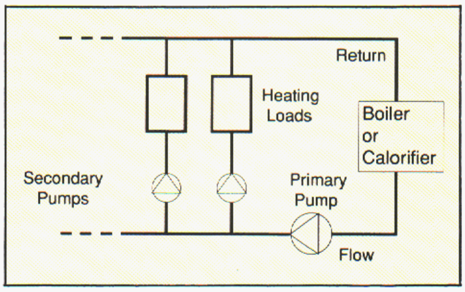


Fig. 5 A typical LTHW heating system

supplying LTHW directly from the boilers or alternatively from calorifiers heated by steam or MTHW. Normally the secondary pumps run continuously.

Worthwhile electrical savings can be achieved by switching off the secondary pumps in response to the thermostat control. In one hospital further steps have been taken to ensure the secondary pumps do not run unnecessarily. Using an ambient temperature sensor, all the secondary pumps are shut down when the temperature exceeds 16°C and the building can maintain an acceptable internal temperature. This has been very successful, providing both electrical savings and heat energy savings.

A heating circuit as depicted in Figure 5 also presents the opportunity to fit a variable speed drive to the primary pump. Linked to a pressure sensor in the feed line, the variable speed control will be beneficial where secondary pumps are being switched on and off according to demand. A payback within 2 years should be achieved from such a measure.

Chiller Plant

During the warmer months the chiller plant is often one of the largest single consumers of electricity in the hospital. The chiller normally provides cooling for the air conditioning plant which in most hospitals is restricted to operating theatres and areas with high internal heat gains such as the X-Ray department. To minimise energy cost the chiller plant should run the minimum number of hours at the maximum efficiency. Minimum running hours can be achieved by ensuring that:

- Chiller plant is switched off if there is no demand for cooling from the air conditioning units. The off-load running consumption of chiller plant is often quite high even though no cooling duty is being performed.
- Maximum benefit is gained from ambient air cooling whenever possible. One hospital ensured that this was achieved by installing an ambient temperature thermostat that stops the chiller plant when the temperature drops below 14°C. The plant is restarted when the ambient temperature rises above 16°C. In this case the plant running hours were halved saving an estimated £3,000 per annum.

Maximum efficiency of chiller plant can be achieved by:

- Running a number of smaller packaged units switching in and out (sequencing) according to demand rather than one big unit operating on proportional control. Compressors are generally inefficient on part load or proportional control.
- Ensuring that records are maintained of chiller plant parameters such as compressor suction and discharge pressures and temperatures. Analysis of this information by suitable trained staff will enable inefficiencies, such as condenser or evaporator fouling, to be detected. Manufacturers' literature will have to be consulted for comparison with ideal settings.

Variable speed pumps are unlikely to be economic on the chilled water circuit due to the low number of operating hours. A policy of switching the pump off whenever possible is the most practical.

Lifts

Hospitals lift motor generator sets can account for over 10% of electricity consumption. Often the sets run continuously even though the demand for lifts reduces during the night.

Two options are available:

- Shut down certain lifts during the night .
- Install run-on timers to all lifts to shut down the motor generators after a pre-set period consistent with the number of starts per hour that can be tolerated by the motors. A run-on time of 10 minutes may prove the optimum.

The latter option presents a very good payback period and has been implemented with success already in some hospitals.

Boilerhouse

Electricity savings in the boilerhouse are fairly limited. However, three points need to be remembered.

- Optimum sequencing of boilers should be maintained to ensure that the minimum number of boilers are operating thereby saving combustion air fan electricity as well as heat energy.
- LTHW boilers feeding directly to the heater circuits use less electricity for pumping than running a steam boiler/calorifier combination which involves the use of boiler feed water pumps.
- It may be worth using variable speed drives on fans in large boilers.

The conversion of the boilerhouse to LTHW cannot be justified on electrical savings alone but these should be taken into account when considering any future boilerhouse changes.

Maximum Demand Charges

Maximum Demand Charges normally represent between 5% and 10% of annual electricity costs. Demand charges are usually incurred during the months, December to March, and it is worthwhile ensuring that the load profile, as depicted in Figure 4, is flattened out as much as possible. Some re-scheduling of plant start-ups and utilisation will help although the scope is restricted in a hospital. The introduction of automatic load shedding is a viable proposition. This will normally consist of automatically switching off certain non-critical plant in a priority sequence as the maximum demand reaches a pre-determined level. This can be done by a purposely installed maximum demand controller or by a Building Energy Management Systems (BEMS) if one is already installed. Items which should be considered for shedding are:

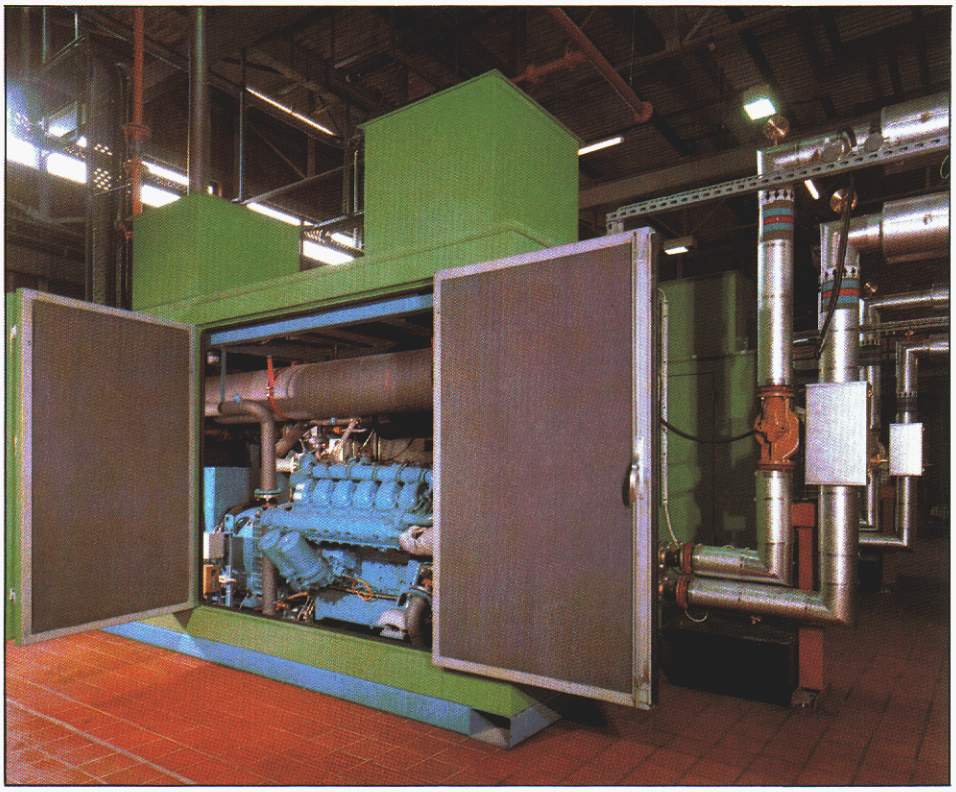
- non-critical ventilation plant (such as in wards and administration areas)
- certain lift motors
- non-essential chiller plant
- banks of lighting if switching arrangements allow.

Power Factor Correction

Most electricity tariffs penalise Power Factors below 0.9 or even higher. The introduction of a suitable bank of capacitors on a phased switching arrangement will ensure that the Factor is kept above the penalty level. The introduction of Power Factor correction equipment should be considered if penalties are being incurred since the payback period will normally be under two years.

Combined Heat and Power

Whilst the introduction of Combined Heat and Power (CHP) will not directly save electrical energy the cost benefits can be significant. The optimum CHP plant should be sized to match the minimum heating requirements of the hospital taking into account space heating, laundry, sterilising and domestic hot water systems. Such a plant will typically only produce 20-30% of the electrical requirements but it will usually provide a payback period of three to four years. A larger system could be installed if absorption chilling is included to provide the air conditioning cooling requirements through the summer. Detailed guidance is given in GPG 60; CHP in the Health Service.



A CHP installation

Other Areas with Potential

So far only the major electricity consumers have been considered. However, as seen in Figure 3, a large proportion of consumption, designated 'Others', will result from numerous small users around the site. The following examples illustrate other opportunities to save:

- Apply automatic timer switches to heated trolleys to ensure that they are not switched on earlier than necessary and not left switched on.
- Optimise cold storage facilities, such as in laboratories and kitchens, to ensure a minimum number of fridges are used and operating efficiently.
- Ensure X-Ray machines, film processors and other significant individual consumers are switched off when not required.
- Fit timers to kitchen ceiling extract fans to ensure they do not run unnecessarily.
- Ensure that office equipment, such as computer printers etc are switched off in the evening.
- Eliminate the use of electric fires for localised heating.

Monitoring and Targeting (M&T)

An important step towards maintaining minimum electricity consumption is the implementation of a regular monitoring and reporting procedure. The feedback of information on consumption levels is essential to ensure that any adverse variances are recognised and a course of remedial action initiated.

Unlike heating energy, which can be related quite confidently to degree days, electricity consumption has many influencing factors such as degree days, outside light levels, occupancy etc. Unless the electrical consumption can be broken down into manageable account centres, such as the boilerhouse (see Figure 6) it will be impossible to target against any one parameter.

The installation of some submetering is essential to introduce more defined electrical consumption areas and place accountability on the people that use it. The gradual trend towards accurate departmental costing will require this sort of information. The implementation of successful monitoring and targeting systems has resulted in electrical savings of between 5% and 15%. On this basis, 5% of the annual electricity consumption could be spent on the installation of electrical submeters with the reality of a 12 month payback period. Unless these submeters are installed and consumption records maintained and analysed, good housekeeping measures will not be sustained and the success of conservation projects are unlikely to be recognised.

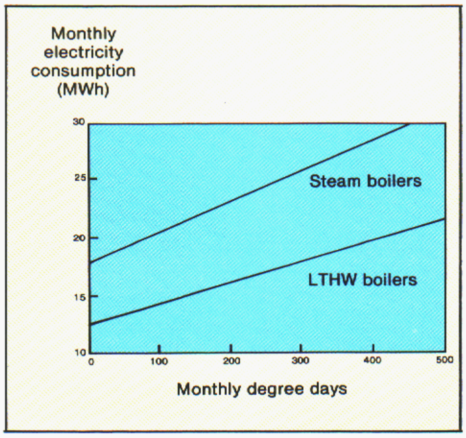


Fig. 6 Boilerhouse electricity consumption

Setting of Automatic Controls

In most of the examples of electrical energy saving, covered in this document, the saving has been achieved by automatically turning equipment off when it has not been required. Whilst the placing of reliance on automatic controls is very much better than expecting manual control to achieve the same result, one should not assume that automatic controls are infallible. In commissioning automatic controls it often takes time to determine settings, eg for temperature and time, that minimise energy consumption whilst only just satisfying other requirements. The maintenance of these optimum settings over a long time period should not be ignored as unauthorised adjustments are often made to overcome temporary problems. Consumption monitoring should be able to detect any significant variances from the expected figures.

Level of Savings

Electrical savings of 15% to 20% may be possible in some locations as a result of implementing projects with paybacks of three years or less. On this basis the total saving would be worth between £20 and £25 million per annum, equivalent to a reduction in overall NHS energy costs of about 7% ie almost half the NHS target saving figure.

For further information on this or other buildings-related projects, please contact: Enquiries Bureau, Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Garston, Watford WD2 7JR. Tel No. 0923 664258. Fax No. 0923 664097.

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